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THE RELATIONSHIP BETWEEN THE FINANCIAL INNOVATION AND THE MONEY SUPPLY: EMPIRICAL STUDY ON THE MAGHREB COUNTRIES

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Abstract. This article examines the relationship between money supply and financial innovation in the Maghreb countries over the period of 1980–2018 for a large annual data set on five Maghreb countries using the panel autoregressive distributed lag model (PANEL-ARDL). The results obtained from the cointegration technique of Pesaran and Shin (1999) confirm that a long-term relationship exists between M2 and its determinants: GDP, inflation, and the credit interest rate. Above all, the results of the research show that mobile money positively and significantly influences the money supply both in the strict sense and in the broad sense. Also, the number of ATMs positively but not significantly influences the supply of money in the broad sense. Failure to take into account the expansion of the number of ATMs can therefore lead to a poor specification of the money supply, and monetary authorities need to explicitly integrate the effect of financial innovation for effective policy action to stabilize economies.

Keywords*: Financial innovation, Maghreb economics, Money supply function, Panel-ARDL.*

JEL Classification: C20, E43, E53, G20

INTRODUCTION

The quest for stability and efficiency in the payment system aimed at ensuring sustainable economic growth is fundamental for central banks in all economies. The payment system provides means favouring the settlement of commercial transactions and other activities economic In the Maghreb countries, this trend towards the transformation of the system and means of payment has increased following the financial liberalization of the 1990s. The impact has been evident in the way financial services are provided to clients. A set of financial innovations has been developed, which can be defined as the introduction of new financial instruments (mobile money payment, bank cards we call it an automated teller machine (ATM)) (Ndirangu & Nyamongo, 2015). Traditional methods of distributing financial services have given way to new distribution technologies including electronic banking products, ATMs, and bank cards. Similarly, the development of mobile communication networks and access to the telephone by all population, both urban and rural, have revolutionized the supply of financial services. Mobile money has made it possible to develop financial services in order to meet the needs of unbanked population. Available data show that in the Maghreb

countries, according to some sources, 70 million of the population have a mobile money account, or around 21.9 % of the working population. Transactions carried out reached $ 19.2 billion in 2017, an increase of 14.3 % compared to 2016 (GSM Association, 2020). In the field of monetary economics, the impact of the emergence and use of electronic money on the conduct of monetary policy has quickly become an object of study. According to the theoretical work related to the request for money, the heavy use of electronic money destabilizes the demand for money (Weil, Mbiti & Mwega, 2012; Dritsakis, 2011; Misati *et al.*, 2010). Electronic money (financial innovation), which complicates the environment in which the central bank operates, limits the way in which the economy reacts to monetary policy and reduces the reliability of monetary aggregates basis for making monetary policy decisions. The growing use of electronic money has revived empirical work on the determinants and the stability of the demand for money in OECD countries all over the world (Nampewo & Opolot, 2016; Hye, 2009; Taylor, 2007). In Africa, with the wave of financial innovations, several studies (using various methodologies, periods and variables of financial innovation) have been conducted on the effect of financial innovation and the stability of the demand for money in several countries, but the results of these studies are still mixed in terms of the sense of the relationship between money supply and financial innovation and its impact on the stability of money demand (Nampewo & Opolot, 2016; Ndirangu & Nyamongo, 2015). It should be noted that these studies are mostly focused on a single country.

1. LITERATURE REVIEW

From the appearance of the first financial innovations, the debate in the literature on their implications for the conduct of monetary policy has surfaced. With the development of payment instruments competing with the base currency, which tend to replace the latter, the central bank currency is no longer a relevant operational target, nor a judicious channel for transmitting political impulses from central bankers (Woodford, 2000). As such, the transformation of the payment system and means, in particular the emergence of electronic money, has sparked a lively theoretical debate on its impact on the money supply. Some authors argue that increasing the use of electronic money can make it difficult to monitor and measure the monetary base (Friedman, 1999). In accordance with this logic, financial innovation destabilizes the demand for money by inducing a variation in velocity of money and thereby limiting the determination of the interest rate. The Central Bank will continue to monitor the issue of this new form of money through the obligation to build up reserves on each electronic monetary unit issued in order to limit the disconnection between the Central Bank and the quantity of currency in circulation (Anderloni, Llewellyn & Schmidt, 2009). Moreover, this heavy use will increase the trickledown effect of the interest rate in the transmission of monetary policy by implying that the current and anticipated variations in the rate of interest are quickly transmitted to the prices of financial assets and thus influence the long-term interest rate, as well as consumption and investment (Jenkinson, Penalver & Vause, 2008). This debate shows that the impact of

financial innovation can relate to the channels of policy transmission (Friedman, 1999). Thus, it has led to several empirical studies in order to confront theoretical speculations with the facts. However, we will focus more on work in developing countries, product of monetary policy. Although there are studies examining the effect of financial innovation on the transmission mechanisms of monetary policy (Weil, Mbiti & Mwega, 2012; Misati *et al.*, 2010), most studies have examined the effect of financial innovation on the demand for money insofar as it is a shock with permanent effects on the demand for money similar to productivity shocks in production functions. Consequently, these studies through different methodologies have led to contradictory results depending on the study context and the financial innovation indicator chosen. To this end, Ndirangu & Nyamongo (2015) studied whether the waves of financial innovation that occurred in Kenya had affected the long-term stability of money demand there. Their results showed that the strong expansion of financial innovation did not cause a structural break in the long-term relationship of demand for money. Thus, the latter remains stable and well integrated with its main determinants. In a similar vein, Weil, Mbiti & Mwega (2012) analysed the implications of innovations in the financial sector on the conduct of monetary policy. Since 2007, monetary policy implications of electronic money have been minimal due to the fact that mobile money transactions are even smaller compared to other monetary aggregates.

2. DATA

We consider the annual data covering the period of 1980–2018 in the Maghreb region: Algeria, Morocco, Libya, Tunisia, and Mauritania. These countries have been selected based on the available data, and our choice for the Maghreb countries has been based on two more reasons: first, this region of the world is the one that registers the smallest number of financial innovations and mobile currency; secondly, we want to highlight, based on the literature, various options of mobile money in these economies since they belong to several monetary unions, such as the Dinar of Maghreb, which is obtained from the sum of the gross added values of all the producers resident in each country. M1 includes currency outside banks plus demand deposits in commercial banks. M2 includes M1 plus quasi money, which includes savings and term deposits. M2 also includes residents' deposits in foreign currency. Consumption Price Index (CPI) represents the level of inflation in the economy, i.e., changes in the cost of a basket of goods and services purchased by the average consumer with the year 2010 base 100. The interest rate is represented by the credit interest rate. It has been chosen based on the availability of data from all the elements of the panel; the first measure relates to the number of ATMs in each country collected on the basis of the International Financial Services of 2015, and the second measure refers to the existence of money mobile in the economy. It has a binary variable, which takes the value of 1 if it is possible to carry out financial transactions through the mobile phone and 0 if not. With the exception of the second measure of financial innovation, all other variables are logarithmic. Thus, our sample covers five countries in North Africa from 1980 to 2018, which has 39 observations per country (NxT) = 195. In terms of size, our sample is well above

those used in previous studies quantifying the effect of financial innovation on the demand for money. As an illustration, apart from the study by Weil, Mbiti and Mwega (2012) that examined the effect of financial innovation in three countries, the other studies focused on one country. Consequently, our study appears to be a pioneer in the Maghreb countries, which assesses the effect of financial innovation on the demand for money by covering five countries.

3. RESULT AND DISCUSSION

In this section, we propose to test our theoretical result: financial innovation destabilizes the money supply function in the Maghreb economies. With regard to the availability of data, we use panel data techniques to estimate the models. As we mentioned above, with nonstationary time series, the variables can be cointegrated, so we must examine the long-term relationship as it is usually the case for money demand functions. Therefore, before estimating these relationships, we perform panel unit root testing and existence of the cointegration relationship.

3.1. Panel Unit Root Co-Integration Tests

Panel unit root tests are used to examine the degree of integration of money supply and financial innovation, as well as other economic and financial variables. Unit root panel tests are suggested as alternative tests to analyse the stationarity of financial innovation and money supply in the panel structure as these tests capture country-specific effects as well as allowing heterogeneity in direction and in the magnitude of the parameters. To study the existence of unit roots in our series, we use three different unit root panel tests, including Levin, Lin and Chu (LLC); Im, Pesaran and Shin (IPS); Maddala and Wu, and Choi. For each technique, we test the presence of the unit root in panel using two types of models. The first model contains a constant, while the second integrates the constant and the trend; the most widely used LLC (2002) test uses the Augmented Dickey Fuller (ADF) test, which is based on the assumption of panel homogeneity. The IPS test (2003) is an extension of the LLC test (2002). This test relaxes the hypothesis of panel homogeneity by allowing heterogeneity in autoregressive coefficients for all panel members. However, these two tests assume independence in cross-section between the elements of the panel. However, to take into account possible correlations among countries in our sample, we have used the Maddala and Wu (1999) and Choi (2001) tests. In our sample, the Maddala and Wu (1999) and Choi (2001) test appears to be superior to the IPS test; it is a non-parametric test based on the Fisher test and relaxing the hypothesis of the unit root process common to all members of the panel. Furthermore, the result obtained on the basis of this test does not depend on the different leg in ADF regressions. We have chosen the following variables:

GDP – gross domestic product;
M1 – the narrowest definition of money;
M2 – a broader definition of money;
CPI – consumer price index;
IR – interest rate;

FI – financial innovation.

3.1.1. Panel Cross-Section Dependence Test

We may test for cross-section dependence in a series in a panel structured work file. There are a variety of tests for cross-section dependence in the literature, and EViews offers the following tests:

Breusch-Pagan LM;

Pesaran scaled LM;

Baltagi, Feng, and Kao bias-corrected scaled LM;

Pesaran CD.

Table 1. Cross-Sectional Independence Test Results

Variable/test	Breusch-Pegan LM	Pesaran scaled LM	Baltagi, Feng, and Kao	Pesaran CD
GDP	3.645 (0.438)	2.623 (0.1 37)	4.532 (0.246)	3.141 (0.184)
M1	2.014 (0.332)	3.887 (0412)	2.705 (0.229)	2.705 (0.229)
M2	3.496 (0.739)	3.2 67 (0.331)	3.267 (0.3 31)	1.955 (0.812)
IR	4.519 (0.119)	6.245 (0.287)	6.245 (0.287)	4.133 (0.317)
CPI	6.885 (0.991)	6.885 (0.756)	4.436 (0.301)	6016 (0.765)
FA	5.367 (0.331)	1.997 (0.211)	1.454 (0.482)	2.436 (0.495)

Note: (.) *p*-value

According to the results of the four tests, it is clear that the variables do not suffer from cross-sectional dependence; thus, the alternative hypotheses of cross-sectional dependence are rejected, i.e., the shocks in one sample do not affect other countries in terms of all variables.

3.1.2. Panel Unit Root Test

We have chosen in this section the second generation cross-sectional dependencies that are based on factor structure, such as Bai and Ng (2001, 2002, 2004), Moon and Perron (2004), Phillips and Sul (2003), Im, Pesaran & Shin (2003), Choi (2001).

Table 2 presents the results of the unit root test under the hypothesis of dependence between members of the panel. It appears that all variables are stationary at 1st diff in the model with individual constancy, while in the model with individual constant and trend, it fails to reject the null hypothesis of no cointegration between variables for all the statistics.

Table 2. Unit Root Test Results (2nd Generation Tests)

PES–CADF					
Variable	**Constant**	**Constant and trend**	**Variable**	**Constant**	**Constant and trend**
GDP	−1.478	0.128	**ΔGDP**	−12.467*	−12.004*
M1	−0.671	0.784	**ΔM1**	−11.638*	−11.453*
M2	−0.703	−1.085	**ΔM2**	−07.749*	−08.715*
CPI	−0.468	−1.196	**ΔCPI**	−09.539*	−09.651*
IR	−1.083	−0.861	**ΔIR**	−08.473*	−08.652*
FA	−0.539	−0.954	**ΔFA**	−06.904*	−06.998*
CIPS					
Variable	**Constant**	**Constant and trend**	**Variable**	**Constant**	**Constant and trend**
GDP	−1.577	−2.256	**ΔGDP**	−5.988	−4.847
M1	−1.0847	−2.159	**ΔM1**	−5.375	−4.957
M2	−1.667	−1.996	**ΔM2**	−5.482	−5.315
CPI	−2.011	−1.785	**ΔCPI**	−4.917	−5.926
IR	−1.904	−2.213	**ΔIR**	−5.736	−5.693
FA	−2.054	−1.894	**ΔFA**	−5.085	−4.913

Notes: H_0: homogeneous non-stationary; general to particular based on F joint test; critical values, CIPS with constant: 10 % (−2.03), 5 % (−2.11), 1 % (−2.25); critical values CIPS with constant and trend: 10 % (−2.54), 5 % (2.62), 1 % (−2.76); * indicates significance at the 1 % level

Regardless of the specification of the deterministic component considered, we can conclude that there is a long-term equilibrium relationship between the variables when we consider cross-dependence in the panel.

3.2. Cointegration Panel Test

After confirming the absence of cross-sectional dependence and the *I*(1) series obtained from unit root tests, we proceeded with the co-integration tests.

According to Westerlund's cointegration test for the existence of a long-run relationship between variables, all test statistics reject the null hypothesis of no cointegration at the five per cent level. Results suggest that cointegration exists and the series are expected to move together in the long-run.

Table 3. Westerlund's Cointegration Test Results

Test	**Statistic**	**Z-value**	**P-value**	**Robust P-value**
G_t	−3.247	−5.506	0.047	0.039
G_a	−1.549	−8.304	0.019	0.018
P_t	−5.889	−6.687	0.018	0.023
P_a	−7.168	−9.044	0.034	0.018

Notes: H_0: no cointegration; lags and lead automatically selected by AIC criterion with Bartlett-Kernel window width set according to $4(T/100)^{2/9} \approx 3$; robust *p*-value controls for cross-section dependence

3.3. Panel Cointegration Modelling

The third step in our empirical work involves investigating the long-term relationship between financial innovation and the supply of money. The analysis of the relationship between money supply and financial innovation in developing countries has been the subject of several studies that differ by the measure of financial innovation and the econometric approach retained. To study the effect of financial innovation on the money supply in Kenya over the period of 1998–2013, Ndirangu and Nyamongo (2015) used an autoregressive distributed leg model (ARDL) since all their statistical series did not have the same order of integration. They started from a dynamic specification allowing them to distinguish long-term effects from short-term effects simultaneously. Weil, Mbiti and Mwega (2012) also studied the stability of the demand for money following the appearance of financial innovations in a sample of five countries between 2000 and 2011, using a univariate analysis. Sichei (2012) used the cointegration technique of Johansen and Johansen (1990) in the case of Kenya during the period of 1985–2010. Odularu (2010) and Odularu and Okinboye (2009) focused on the cointegration technique of Engle and Granger in the case of Nigeria to highlight the relationship between money supply and financial innovation. With this in mind, we propose using the Pooled Mean Group (PMG) method, the principle of which we outline before explaining the actual implementation. In addition, in order to confirm our choice, we compare the results of this method with those obtained by two alternative methods, notably those of the Mean Group (MG) and Dynamic Fixed Effects (DFE). Thus, PMG estimates will not be consistent, while MG estimates will give consistent estimates of the average of long-term coefficients among countries. To ensure that the estimation is consistent and efficient, the Hausman test is sometimes described as a test for model misspecification. In panel data analysis (the analysis of data over time), the Hausman test can help choose between a fixed effect model or a random effect model. The null hypothesis is that the preferred model is random effect, and the alternate hypothesis is that the model is fixed effect (Pesaran, Shin & Smith, 1999). An invalid restriction on the parameters in dynamic models generally results in underestimating the speed adjustment. In our study, the Hausman test shows that the PMG estimate is the most appropriate; therefore, we introduce a subgroup of long-term homogeneity restrictions. The empirical results are obtained by assuming that the residuals are normal and, therefore, the likelihood model in the panel is obtained as the product of the likelihood of each country. Maximising this likelihood simultaneously estimates the long-term and adjustment coefficients for each country. The maximum likelihood method allows us to have, from long-term coefficients, short-term coefficients country by country as well as their error variances.

Table 4 presents the results of the estimation of the long-term coefficients stemming from the stacked regressions of the effect of financial innovation on the money supply in the broad sense in the Maghreb countries with the number of ATMs and the existence or absence of mobile money representing the measure of innovation financial.

Table 4. Results of Modelling for Broad Money M2 on the Dynamic Panel Data

Long-term coefficients	**M2**		
	PMG	**MG**	**DFE**
GDP	3.665*** (0.000)	2.339* (0.007)	0.586*** (0.000)
CPI	−6.118*** (0.000)	−3.411 (0.218)	3.223** (0.01)
IR	0.653 (0.112)	−1.397 (0.493)	−1.415** (0.03)
FI	0.775** (0.04)	0.397*** (0.000)	-0.308 (0.037)
ECT(−1)	−0.341*** (0.000)	−0.231*** (0.000)	−0.176*** (0.000)
Hausman test	1.365 (0.177)	–	1.996 (0.882)
Number of observations	195	195	195

Source: Developed by the author. The significance at 1, 5 and 10 % significance level.

This analysis of the effect of financial innovation on the money supply focuses on the results of PMG. However, the results of the MG and DFE estimators are useful for comparison purposes. The main results obtained are the following:

PMG estimates illustrate that GDP and (CPI) are significant at 5 % and have the expected sign. The lending interest rate is positive and not significant. In the case where financial innovation is captured by the existence of mobile money, the latter positively and significantly influences the supply of money in the broad sense. The results of Hausman test confirm that the assumption of homogeneity of long-term coefficients cannot be rejected regarding the relationship between financial innovation and the supply of change. Conversely, the results show the effect of financial innovation measured by the number of ATMs, which has a significant negative effect on the demand for money. Likewise, in this case, the results of the Hausman test confirm that the assumption of homogeneity of long-term coefficients cannot be rejected concerning the relationship between financial innovation and the demand for money in the broad sense. Considering the two measures of financial innovation, the estimated average coefficient relating to the error correction term is negative and significant, thereby confirming the long-term or equilibrium relationship between the supply of money in the broad sense and its determinants. The magnitude of this speed adjustment in demand for broad money is important enough that ignorance of it would introduce bias into the estimation of long-term parameters.

Table 5 presents the results of the estimation of long-term coefficients from the stacked regressions of the effect of financial innovation on money supply in the strict sense in the Maghreb countries. These results are presented both for the innovation measured by the number of ATMs and by the existence or absence of mobile money. The analysis of these results also focuses on the PMG estimate, and the other estimates are presented for comparison.

Table 5. Results of Modelling Strict Money M1 on the Dynamic Panel Data

Long-term coefficients	**M1**		
	PMG	**MG**	**DFE**
GDP	4.556*** (0.000)	3.419* (0.08)	0.141 *** (0.000)
CPI	−7.308*** (0.000)	−4.498 (0.578)	5.416** (0.01)
IR	0.988 (0.561)	−2.525 (0.388)	−0.922 ** (0.03)
FI	1.284 ** (0.03)	0.652 *** (0.000)	-0.288 (0.067)
ECT(−1)	−0.114 *** (0.000)	−0.669*** (0.000)	−0.448 *** (0.000)
Hausman test	1.012 (0.902)	–	2.542 (0.402)
Number of observations	195	195	195

Source: Developed by the author. The significance at 1, 5 and 10 % respectively (***), (**) and (*)

PMG estimates illustrate that GDP and inflation are significant at 5 % and have the expected sign, while the interest rate is positive and significant. If financial innovation is captured by the existence of mobile money, the latter positively and significantly influences the money supply in the strict sense. Hausman test results confirm that the assumption of homogeneity of long-term coefficients cannot be rejected concerning the relationship between financial innovation and the money supply. Similarly, the results show that the effect of financial innovation measured by the number of ATMs also has a positive and significant effect on demand for money in the strict sense. The results of the Hausman test confirm that the hypothesis of homogeneity of long-term coefficients cannot be rejected concerning the relationship between financial innovation and the strict money supply M1. Considering the financial innovation, estimated average coefficient relating to the error correction term is negative and significant, thereby confirming the long-term or equilibrium relationship between the supply of money in the strict broad sense and its determinants. The magnitude of this speed of adjustment in the money supply is large enough that, if it is not taken into account, would introduce biases in the estimation of long-term parameters.

CONCLUSION

We have analysed how financial innovation in terms of the number of ATMs and mobile money influences the dynamics of money supply. The econometric study has been conducted for the Maghreb countries for the period of 1980–2018. The results have shown that mobile money positively and significantly influences the offer, both in the strict and the broad money. Moreover, as regards the number of ATMs, its influence is positive and significant for the supply of money in the strict sense and not significant for the demand for money in the broad sense. These results are especially important because they show that today the central banks of

the Maghreb countries integrate the development of innovation into their monetary policy strategy to better enable financial inclusion for those excluded from the traditional banking system. Consequently, it appears that financial innovation counts and plays an important role in determining the function of money supply, and its fluctuations in the Maghreb countries.

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